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A New Colour-Texture Feature Extraction Method for Image Retrieval System Using Gray Level Co-occurrence Matrix

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Abstract

Proposed a new colour-texture feature extraction method is presented for Content Based Image Retrieval (**CBIR**) system using Gray Level Co-occurrence Matrix (**GLCM**). In this method, **Colour-GLCM** (**C-GLCM**) is extracted from each colour channel, and then computes the average of each column of **GLCM** matrix for each channel. In this case, we will get a feature vector include colour and texture features at the same time to achieve the objectives of any **CBIR** system which are; decrease the Feature Vector (**FV**) dimensions which consequently reduces retrieval time, and also increase the retrieval accuracy. To perform the evaluation of the proposed **CBIR** system, **4000** test images have been used as query images including 500 original images were selected randomly from image database of Iraqi National Museum of Modern Art, then applying seven image transformations on each original image resulting **3500** transformations image sued as query image. The proposed **C-GLCM** algorithm has led to improve and increase the retrieval accuracy (**93.63%**) comparing with **GLCM** that extraction from whole gray image (**87.88%**) and comparing with statistical properties that extraction from **GLCM** feature (**80%**).

Keywords: Content Image Retrieval System; Pre-Processing; Feature Extraction; Colour and texture features; **GLCM**; **Colour-GLCM**

1. Introduction

Recently, the advancement in multimedia acquisition devices such as scanner and digital cameras sensor, has led to exponential increase of images collection, audio, and video in various and numerous real application areas such as medical imaging, criminal investigation, trademark registration, museum and art galleries, etc. Searching among these images to find the desired image has become costly problem. The problem with existing and widely adapted method for text-based image retrieval are done manually and proved to be difficult, time consuming and insufficient. Therefore efficiently and effectively automatically retrieve the desired images from large and varied image databases is now a necessity. This system is commonly known as **C**ontent-**B**ased **I**mage **R**etrieval (**CBIR**) system, which is defined as any system that helps to organize, retrieve, archive, and brows the image by its visual content [1], [2]. **I**mage **R**etrieval **S**ystem (**IRS**) is an active research in computer vision and database management since more than 25 years, causing in important request for design an efficient system for multimedia information retrieval [1]. Retrieval of images is the active and effective research subject in information retrieval [3]. **D**ata**B**ase **I**mages (**DBIs**) are indexed by their own visual low-level features (colour, texture, and shape) and retrieve images based on visual similarity in appearance to the **Q**uery **I**mage (**QI**) [4]. Three important characteristics that must be available in **CBIR** system to be an optimal system; low computational complexity, low retrieval time, and high retrieval accuracy [5]. The key in accomplishing an effective **IRS** using **CBIR** approach is to select the most proper low-level features that represent the image as unique much as possible using one of feature selection method to increase the efficiency of **IRS** [6]. The features selections have to be sufficient and discriminative in describing the content present in the image. Texture analysis takes a significant and valuable area of the research in machine vision and in image processing. Most of the natural surfaces show texture, the efficient system must be capable of dealing with the texture world around it. Texture like colour feature, it is one of the most important and a robust feature for image retrieval and image recognition systems; it refers to visual patterns that have properties of homogeneity that do not result from the presence of only a single colour or intensity. Texture is defined as a structure of surfaces formed by repeating a particular element or several elements in different relative spatial positions. Generally, the repetition involves local variations of scale, orientation, or other geometric and optical features of the elements, it contains important information about the structural arrangement of surfaces and their relationship to the surrounding environment, such as; clouds, leaves, fabric, tree bark, fabrics, water, etc. Typically, texture features methods calculate the degree of uniformity, roughness, contrast, frequency, coarseness, directionality, density, regularity, linearity, and phase [7], [8].

2. Literature Review

Since the early 1990s, CBIR has become an active field for researchers, many algorithms and literature addressing this approach. Instead of being manually annotated by text-based keywords, images in **CBIR** were indexed by their own visual content. [9], [10], [11] conducted an excellent survey in the field of **CBIR** which emphasized on two fundamental bases; visual feature extraction method and retrieval system design. Recently, many methods are developed for extraction of such features; [12] they proposed an effective Genetic Algorithm (**GA**). They computed the mean and standard deviation from colour feature; also they extracted **GLCM** as texture features and computed some statistical features from **GLCM** like entropy. The proposed method gives a good retrieval results as the users' expectation. [13] They have extracted global (from whole image) and local (from sub-image) colour histogram as a colour feature using **HSV** colour space. While for texture feature, they have extracted **D**iscrete **W**avelet **T**ransform (**DWT**). Then, for matching process, they used different similarity metrics such as Euclidean, Canberra and City-block distances for comparison purpose between the retrieval results obtained by each one. Lastly, they have compared between all the results obtained by using different **F**eature **E**xtraction (**FE**) methods.

3. Typical CBIR System

The principle of the typical **CBIR** system is depending on automatically extracted visual information (colour, shape, and texture) from each image in the **DBIs**, then stores these values in new database called features database [14]. These feature data are of very small size comparing with the raw data of an image. Thus the features database contains an abstraction of pixel values from each image in the **DBIs**. The typical **CBIR** is consisting of three modules as shown in figure (1).

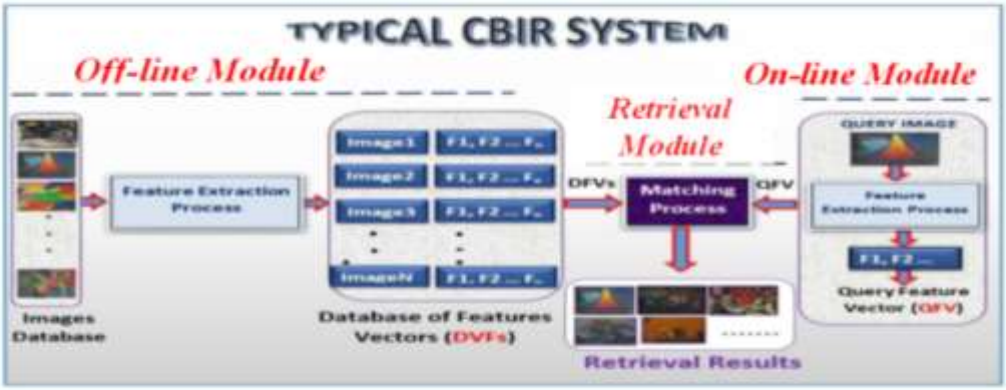


Fig. 1: Block diagram of typical CBIR system

3.1 Off-Line Module

The first and main component of any **CBIR** system is the off-line modules which include; **DBIs** collection, The process of extract the feature descriptors that represent the **FV** of each image in the database then saved these feature vectors (**FVs**) in the database to represent the **DFVs.**

3.2 On-Line Module

On-line module is the process that is done between the **CBIR** system and the system's user by provides the system with **QI**, then the system will be extracted the **FV** of **QI** automatically to form the **Q**uery **F**eature **V**ector (**QFV**).

3.3 Retrieval Module

The last module of any **CBIR** system is the retrieval module. In this module; **DFVs** are loaded, then computing the similarity distance between them with **QFV** using one of the similarity metrics in order to retrieve and display the most similar image to the **QI** that has zero value or lowest distance value. [2], [10], [15].

4. Proposed CBIR System

Figure (2) shows the main components of the proposed CBIR system that will be discussed in details next sections. These components include build the system's database and image retrieval process.

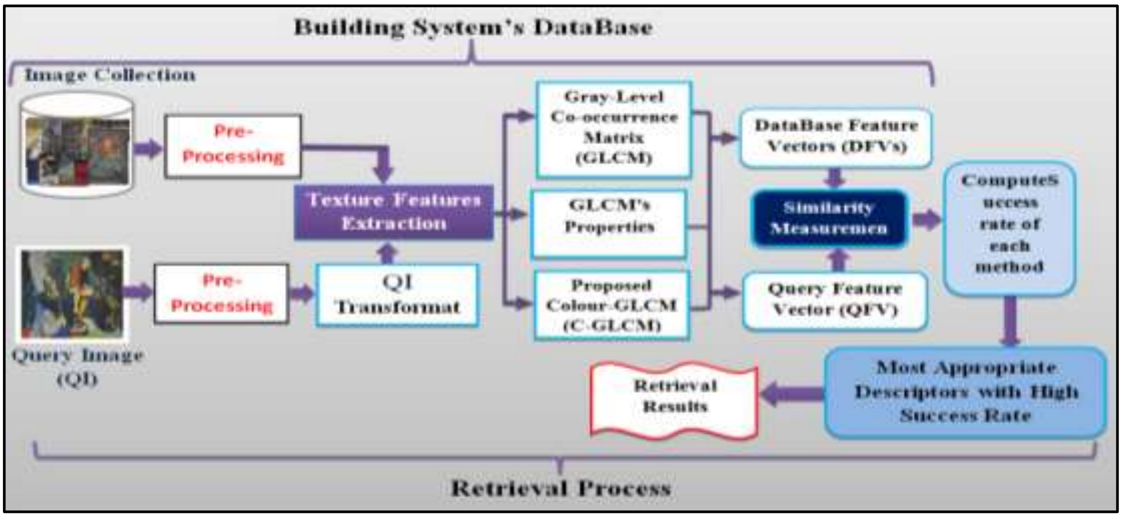


Fig 2: The block diagram of Proposed CBIR system

4.1 Building System's Database

The building system's database is divided into three functions; image collection stage, pre-processing stage, and **FE** stage. Each function is complementary to the other stage and should be done sequentially step by step as shown in figure (2).

4.1.1 Image Collection Stage

The first stage of the proposed **CBIR** system is to create the **DBIs**. Figure (3) displays some images samples of **I**raqi **N**ational **M**useum of **M**odern **A**rt (**INMMA**) used in proposed **CBIR** system.

Fig 3: Samples of images database

4.1.2 The Pre-Processing Stage

The second stage of the proposed **CBIR** system is the pre-processing function which is necessary for most of **IR** system because most of digital images have been obtained using a digital camera and may be irregular in the shape. Figure (4) shows the diagram of pre-processing function of **DBIs**.

Fig. 4: Diagram of the Pre-processing Stages

This stage contain two processes for preparing the images before analyzing them including; firstly, annotated all the images by assigning the suitable image file name manually and secondly, remove the image footnotes automatically to enhance the images using the following algorithm:

Algorithm 1: Remove Image Footnotes (RIF)

Input: **INIDB** {Image Database}

Output: **OUTIDB** {The Target Image without footnotes}

Step1: Load **INIDB (Img**).

Step2: Get an Image from **INIDBs**

Step3: Determine the edge contours of the image (image footnotes) by applying Canny Edge Detection (**CED**), see the reference [16] for more details about **CED** method.

Step4: Fixed the first corner point (first pixel) until the last corner point (last pixel) on the image frame, which represent the first and last pixels of the original image after remove the image footnotes (Two small yellow circles) as shown in figure (5b).

Step5: Resave original image (after remove the image footnotes) in the new database.

Step6: Repeat the steps from (1-5) on all images in **INIDBs**.

-a- -b-

Fig. 5: a: Original image b: Edge map by canny edge

Figure (6a) shows some examples of original database images while figure (6b) shows these images after pre-processing process.

-a- -b-

Fig. 6: a: Before Pre-processing process; b: After Pre-processing process

4.1.3 Feature Extraction Stage

In order to search images based on their contents (features), a **CBIR** system must obtain these content from image collection and **QI**, this process is known as **F**eature **E**xtraction (**FE**) process. **FE** process is the important and major step in any methodology of **CBIR** system where the image data are represented in meaningful and reasonable manner and converted to significant numeric [17]. The main key to perform an effective image retrieval system is to select the proper features that represent the image as strong as possible [2], [18]. In this paper, texture feature is extracted as a global feature.

Texture feature plays a main role in some real applications like image and video retrieval, analysis of medical image, and remote sensing because it provides a good information about the selected image region or the spatial arrangement of intensities in an image [19], [20]. There are various texture features extraction approaches were proposed and developed to improve the performance efficiently of **CBIR** system that used texture as image feature. Generally, texture analysis methods can be classified into statistical and frequency (filtering) methods [21], [22], [23]. The statistical method treats the textures feature as the statistical event or as numeric quantities that represent the statistical properties of the intensities and pixel's position. This approach is less intuitive, easier and efficient to compute, and it is commonly used for segmentation, classification, and image retrieval. **G**ray **L**evel **C**o-occurrence **M**atrix (**GLCM**) [24], run-length matrix [25], local binary pattern that describe textures according to the relationships between the colours components of neighbouring pixels, [26] are examples among the statistical approach. Frequency approach is represents textures in the frequency domain and represents a texture as a set of primitive texels in repeated or regular pattern in an image, Gabor filter [27], discrete cosine transform [28], wavelet transform, etc. are examples of frequency approach [29].

4.1.3.1 Gray Level Co-occurrence Matrix Feature

Gray **L**evel **C**o-occurrence **M**atrix (**GLCM**) feature was introduced by [7]. It is the method of calculating the frequency of pixel pairs having the same gray-level in the image and it has proved to be a common method of texture feature extraction from an image. **GLCM** is called a second-order statistic because it collects the information of the pixel pairs instead of single pixel, it is based on studies of pixel intensity's distribution statistically and it expresses the probabilities **P(i, j | d, θ)** of which two pixels having relative polar coordinates (**d, θ**) appear with intensities (**i, j**) [30]. Also, it can be defined as the sum of times number that the pixel with intensity gray-level value (**i**) occurred in the specified relationship to a pixel with value **j** in the input image. Thus, the following parameters should be specified before computing **GLCM** feature [31], [32], [33].

1. The spatial relationship (angle θ) is defined as the pixel of interest (reference) pixel, and the neighbour pixel is limited to (0o, 45o, 90o, and 135o).

2. The displacement vector **d = (dx, dy)** between the interest pixel and its neighbour pixel over the image, d is an integer number and could take a value of (**1,2,3,…n**).
3. The number of gray levels (**G**), a typical value of **G** is **4, 8, 16** or **32**. The **GLCM's** size is determined by the number of (**G**) [34].

The output is 2D (square) dependence **GLCM** matrix. To get a probability matrix, **GLCM** is normalizing by the sum of the entries. We can get multiple numbers of **GLCM** matrices depending on the different values of (**θ** and **d**) that used to extract it.

4.1.3.2 GLCM properties

Due to the nature of values of **GLCMs** which are sparse and large, Haralick [7] has described fourteen various statistics which are computed from **GLCM** with the purpose of describing the image to get efficient descriptors as texture features vector. In this paper, the following **GLCM** properties are used in the proposed **CBIR** system as texture feature:

1. Contrast

Returns a measure of the intensity contrast between a pixel and its neighbour over the whole image:

$$\sum_i \sum_j (i-j)^2\, p(i,j) \text{ .... } (1)$$

2. Correlation

Returns a measure of how correlated a pixel is to its neighbour over the whole image:

$$\sum_{i,j} \frac{(i-\mu i)(j-\mu j)p(i,j)}{\sigma_i \sigma_j} \text{ .... } (2)$$

3. Energy

Returns the sum of squared elements in the **GLCM**:

$$\sum_i \sum_j p^2(i,j) \text{ .... } (3)$$

4. **Homogeneity**

Returns a value that measures the closeness of the distribution of elements in the **GLCM** to the **GLCM** diagonal:

$$\sum_i \sum_j \frac{p(i,j)}{1+|i-j|} \text{ .... } (4)$$

Where,

Pi,j = Represent the elements of the normalized symmetrical GLCM

μ = Represent the GLCM mean (being an estimate of the intensity of all pixels in the relationships that contributed to the GLCM)

σ = Represent the variance of the intensities of all reference pixels in the relationships that contributed to the GLCM.

3.1.3.3 Improved the Retrieval Accuracy of GLCM Algorithm

To improve the feature extracted using **GLCM**, in this paper, proposed **C**olour-**GLCM** (**C-GLCM**) feature is presented to achieve the objectives of proposed **CBIR,** which include reducing the dimensions of **FV** which consequently reduces retrieval time and increase the retrieval accuracy. The following steps represent the proposed **C-GLCM** algorithm**:**

Algorithm 2: C-GLCM feature extraction method

Input: **DBIs** {Load **D**ata**B**ase **I**mages}

Img: {Original Image}

Output: **C-GLCM** {**C**olour-**GLCM** descriptor}

Step 1: Read **Img**.

Step 2: Apply image resize process.

Step 3: Separate the three image colour channels into red, green, and blue channel.

Step 4: Compute **GLCM** feature with **45** and **135** degree direction and (**8*8**) **GLCM** levels for each channel.

Step 5: Compute the average of each column of **GLCM** matrix for each channel that obtained from steps 4 using the following equations:

Averg**RGLCM** = mean (**RGLCM 45** + **RGLCM 135**),

Averg**GGLCM** = mean (**GGLCM 45** + **GGLCM 135**),

Averg**BGLCM** = mean (**BGLCM 45** + **BGLCM 135**)

Therefore, the length of each average is equal to only (**8**) dimensions.

Step 6: Concatenate the results obtained from step 5 using the following equation:

C-GLCM = [Averg**RGLCM**   Averg**GGLCM**   Averg**BGLCM**]

In this case, the length of **FV** of **C-GLCM** will be **24** dimensions instead of **64** dimension of **GLCM**. Figure (8) shows the flowchart of **proposed C-GLCM** feature extraction met[illegible]

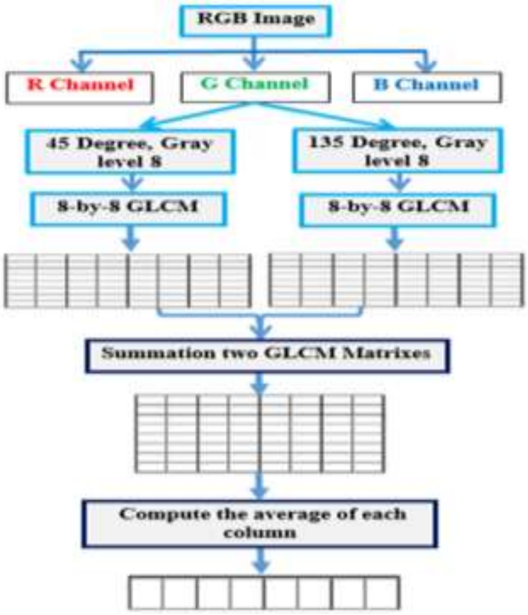
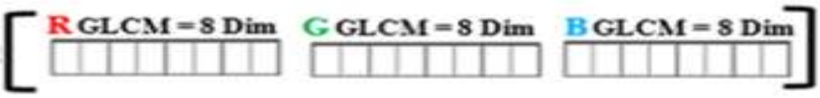


Fig 7: Flowchart of Proposed C-GLCM feature

Thus

FV of C-GLCM =  **= 24 Dim**

4.2 Retrieval Process

In this stage, pre-processing is applied on **QI** as done on **DBIs**, and then the same features that extracted from **DBIs** are extracted from **QI** to obtain **QFV**. One problem may face any **DBIs** that are used in image retrieval system which is each image has been obtained using a digital camera may have different resolution. To overcome this problem, the following seven transformations are applied on the original images, and then used them for test purpose to check whether any changing to **QI**, the system can retrieve the similar images to the **QI** despite the differences in the image resolution.

1. Image Rotation

Rotating, turning, or reversing image allows to correctly displaying an image that may have been taken with a camera at an angle or scanned in a scanner at a different angle. Three image rotations 90, 180, and 270 degree will be done on each original image. Figure (8) shows an example of original image with three rotations.

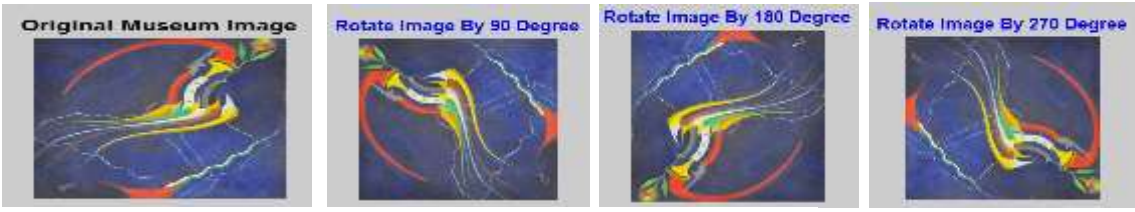


Fig. 8: Original image with three rotations

2. Image Noise

Noise is the undesirable effects produced in the image due to the errors in the process of image acquisition which is affected in the pixel values; so it does not reflect the true density of the real scene. The noise quantity is determined by the number of pixels that is corrupted in the image as a result of noise. In this paper, Salt and pepper noise is applied on all original images; it is one of noise's type among many types of noise. This type of noise contains random pixels and being set to (On pixels) which mean bright pixels on the dark region, and (Off pixels) which mean dark pixels on the bright region. Figure (9) shows an example of one image after adding salt and pepper noise.

Fig. 9: Original image with salt & pepper noise

3. Image Pyramid

The third transformation is transform each original image to image pyramid by computes a Gaussian pyramid expansion for one stage multi-resolution pyramid of the image (I) using equation (5) and the size of image output is equal to:

$$(2*M-1)\text{-by-}(2*N-1) \qquad (5)$$

Where,

M and N represent the size of rows and columns the image.

4. Image Cropping

The process of removing the image footnotes is called image cropping and it is performed in order to improve the image framing. It is limited since it can only remove pixels from the image periphery. Figure (10) shows an example of an original image with cropping it.

Fig. 10: Original Image with Cropping

5. Image Scaling

Image scaling is the process of resizing a digital image. It means reduces or increase the physical size of the entire image by changing the number of image's pixels.

- **Retrieval Algorithm**

The performance of proposed **CBIR** system includes the following stages:

Stage 1: Load one image randomly as **QI**.

Stage 2: Apply pre-processing function.

Stage 3: Apply **FE** process to get **QFV**.

Stage 4: Load **DFVs**.

Stage 5: Compute the similarities between **QFV** and **DFVs** using the common metric that is used in image retrieval system is Euclidean Distance by examining the root of the squared difference between **QI** and **DBIs**, where the value of distance shows the degree of the similarity between **QI** and **DBIs**.

Stage 6: Sort the distance values in ascending order and store them with associated image file in a new database.

Stage 7: Retrieve and display the images which have zero or smallest distance value where represent the most similar image. In some details, if the distance value is equal to zero, i.e. the same image of **QI**, if it is smallest value, this means that the image is most similar to **QI**; else, it is not similar image to **QI**.

4. Experiments and Results

In this section, describes the experiments and results obtained by the proposed CBIR system is presented. The system recorded promising results in retrieving relevant images from the large museum images database that is used to test the performance of proposed CBIR system. Many comparisons to check the accuracy of texture feature using **GLCM** methods used in this paper are discussed and experimented. This database is provided by (**INMMA**), **4000** original images belong to many Iraqi artists have been used as **QI** including **500** original museum images which were selected randomly among all the museum images, then applying seven image transformations that mentioned in section 4.2 on each original image resulting **3500** transformations images. Texture image feature was used as based to retrieve the similarity images. The subsequent experiment is a comprehensive comparison of different **FE** techniques. Visual comparison of the improvement achieved by proposed **CBIR** will be given at the end of this experiment. All experiments were conducted using Matlab 7.10 (2010a) as the software tool and an Intel (R) Core™ 2 Duo, processor with a 2.20 GHz CPU and 8 GB RAM as the testing platform.

To select the suitable **GLCM** texture feature, in this paper, firstly, the **GLCM** feature was applied using the method which mentioned in section (4.1.3.1). We focused on how the spatial relationship (direction) parameter is affected on the retrieval results, while other parameters keep it constant. Thus, several experiments were conducted using four different directions (**0°, 45°, 90°,** and **135°**) to create multiple **GLCMs** for a single input image by scanning the intensity of each pixel and its neighbour, defined by displacement d=1. We can also combine any two or more directions to form an average of **GLCM** matrixes. As a result, the system produces high accuracy with the best angle selection experimentally (**45º** together with **135º**) and G = **8** to compute the **GLCM** feature. A new matrix is formed by sum the elements of matrices which represent the **GLCM** feature vector with **64**-dimention (**8-by-8**). Secondly, statistics metrics that are very useful texture features can be computed from **GLCM** with the purpose of describing the image to get efficient descriptors as texture features vector and to decrease the dimension of **GLCM** vector including homogenous, contract, correlation, and energy properties using the equations (1-4), then two experiments are done to get the FV of **GLCM** are done to retrieve the similarity images; the **first** experiment is by concatenating these four features to form the **FV** with 4- dimension, the **second** experiment is by computing the average for these four features. Last experiment is done using the proposed **C-GLCM.**

5. Performance Evaluation

The evaluation is carried out based on computing the retrieval accuracy for each method of **GLCM** descriptor for each retrieval type. To evaluate **GLCM** descriptors for each type of query image, a new evaluation method called the average of success retrieval rate is proposed to compute the accuracy of retrieval performance of each feature's descriptor by computing the percentage of successful retrieval. The retrieval results by **GLCM** descriptor was considered successful by the user if the original museum image was in the first rank of the returned set. The overall comparison results that obtained using all **GLCM** methods including the proposed **C-GLCM** method are summarized in Table (1).

Table 1: Success retrieval rate of GLCM descriptor methods

Query Image	Success Retrieval Rate %			
	Gray Level Co-occurrence Matrix (GLCM) Methods			
	GLCM 45+135 (64) Dim	Average of Four Properties of 45+135 GLCM (1) Dim	Concatenate Four Properties of 45+135 GLCM (4) Dim	Proposed C-GLCM of 45+135 (24) Dim
Original Image	**100**	**100**	**100**	**100**
Image Rotate 90º	**99**	**100**	**83**	**99**
Image Rotate 180o	**95**	**100**	**100**	**99**
Image Rotate 270o	**95**	**100**	**83**	**99**
Image Cropping	**60**	**49**	**49**	**70**
Salt & Pepper Noise	**70**	**37**	**42**	**86**
Image Pyramid	**85**	**98**	**99**	**98**
Image Scaling	**99**	**60**	**67**	**98**
Average of Accuracy	**87.88**	**80.5**	**80**	**93.63**

The results show that the proposed **C-GLCM** improved the retrieval results with average of success retrieval rate from (**80**% to **93.63**%) which represent the most a proper texture feature descriptor.

6. Conclusion and Feature Work

6.1 Conclusions

In this paper, we have proposed a new **M**useum **I**mage **A**rchiving and **R**etrieval (**MIAR**) system for **INMMA**. This section introduces the major outlines that are concluded from this study as presented in the following points:

1. The experimental results reported promising high retrieval accuracies by using the proposed **C-GLCM** feature. Algorithm development of **GLCM** texture feature by extraction from each colour channel lead to improve and increase the retrieval accuracy (93.63%) compared with **GLCM** that extraction from whole gray image (87.88%) and compared with statistical properties that extraction from **GLCM** (80%). These results come with users’ expectation

2. The proposed **C-GLCM** method produced feature vector contains texture and colour features at the same time with low dimensional.

3. The design of the proposed system is very flexible, allowing the system user to expand the images database because the system is extensible as there is no limitation in adding new museum images at any time.

6.2. Future Works

Although the system performs well, at the current stage, there is much room for enhancement to expand the proposed system to a wide range of retrieval applications. Some possible future works are discussed below:

1. Finding other feature descriptors and feature fusion methods to fuse these descriptors appropriately in order to increase the image retrieval accuracy.

2. Finding automatically a method to annotate the museum images associated with **MIAR** system. This process will lead to retrieve the similarity museum images based on textual information in addition to image content.

Conflict of Interests.
There are non-conflicts of interest

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